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ABSTRACT

Noting that little is known about young children's informal mathematical knowledge and that such knowledge may contribute to national differences in mathematics achievement, this study examined Taiwanese and American preschool children's informal mathematical knowledge and the type of mathematical activities they encounter in everyday life. Data were collected by means of 15-minute videotapes of 114 preschoolers, 4 and 5 years old, from 2 preschools in Taipei and 5 preschools in New York City during free play. There were no gender or social class differences in the amount of time spent in different mathematical activities for either cultural group. Data indicated that Taiwanese children spent significantly more time (about 10 of the 15 minutes) in mathematical activity than did American children (about 6 minutes). Children in both groups were involved in pattern and shape activities more than any other mathematical activities. Taiwanese children spent more time in pattern and shape and in spatial relations activities than did American children, even with Lego and block play held constant. There were no cultural differences in the complexity of play related to magnitude comparison and enumeration. Taiwanese children showed much more complex play with patterns and shapes than did American children. (Contains 15 references.) (KB)

Taiwanese and American Preschool Children's Everyday Mathematics

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The cross-national literature is replete with studies showing that Chinese, Japanese and Korean children demonstrate higher levels of achievement in school mathematics than do American children (McKnight, et al., 1987; Stevenson, Lummis, Lee & Stigler, 1990; Stigler, Lee, & Stevenson, 1990). Many factors can and probably do contribute to the achievement differences—the quality of teaching, home environments, and psychological factors like motivation. One possible factor concerning which we know very little is young children's informal mathematical knowledge. Perhaps Asian children's superior academic achievement can be attributed, at least in part, to an advantage in early informal mathematics.

Research shows that counting is easier for Chinese children and East Asian groups in general (Stevenson, Stigler, Geary, Ginsburg et al.), perhaps because of the logical numerical structure of Chinese and other languages based on it. These languages very sensibly treat 13 as ten-three and 23 as 2-10-3. In comparison, English is confused and irrational. Some have even argued that language is a key factor in explaining why Chinese-speaking children have an edge in calculation over Western children (Miller, Unpublished manuscript; Miller & Parades, 1996; Miller & Stigler, 1987). Miura and her colleagues (1988, 1989) have extended this idea to most East Asian languages, including Japanese and Korean as well, arguing that the underlying base-ten structure inherent in the spoken and written counting numbers of these languages may contribute to East Asian children's superiority in school mathematics.

At the same time, other research on informal mathematics presents a different picture. Results from Song and Ginsburg's (1987) study, for example, show that American 4- and 5-year-old children outperform Korean children in informal mathematical knowledge. Ginsburg's et al. (1997) findings show that American and East Asian children are similar on many aspects of informal mathematics. Their study does not show clear Asian superiority in informal knowledge.

Furthermore, cross-national research is limited in its focus on the three C's—counting, calculation and computation. There is little if any research on the subject of how East Asian preschoolers compare with American peers in terms of spatial and geometric thinking. To our knowledge, not one study examines Asian-American differences in this area. The only tangentially relevant study is that of Lesser and his colleagues (1965), who were interested in comparing general intellectual competencies in the areas of language and mathematics of 6- and 7-year old public-school children of various ethnic groups in New York City. One area in which the children were tested involved spatial thinking, in which the Chinese children scored roughly the same as the Jewish children, and significantly better than African American and Latino children. Lesser's et al. study, however, employed only standardized methods of assessment, which may not provide sufficiently rich or accurate information concerning what children of varying ethnic backgrounds really know about spatial relationships or other areas of knowledge.

Finally, the literature in cross-national mathematics comparisons is devoid of studies examining everyday mathematical behavior in East Asian and American preschoolers. Although we have some information on how well young Asians and Americans count and understand cardinality, we know next to nothing about the kinds of mathematical activities in which they engage in everyday life.

In brief, the literature shows that Asian students out-perform Americans in school mathematics. Yet existing research provides only a limited and sometimes confusing view of cross-national differences in the informal mathematics which might provide a conceptual foundation for later school learning. Some research suggests that the Chinese-based counting system is easier to learn than English and that its transparent base ten structure provides a sounder conceptual basis for learning mathematics than does English. Other research shows little difference in the informal mathematics of Asian and American children. Virtually no research focuses on preschool mathematical knowledge apart from counting and computation. And virtually nothing is known about the everyday mathematical behavior of Americans and Asians.

Consequently, one goal of the present investigation is to contribute to an understanding of possible cross-national differences in American and Asian children's informal mathematical knowledge. Our research compares the everyday mathematical behavior of American 4- and 5-year-old children with Taiwanese peers. We examine not only counting and computation, but also geometrical and spatial knowledge.

Method

Design. This study replicates the data gathering procedures described by Ginsburg et al. (In press). The general idea was to videotape 4 years and 5-year-old children of age during free play, each of whom was videotaped for 15 minutes. We compared the data collected in the earlier study with a new set of data that was collected in Taipei, Taiwan (Republic of China). The duration of free play time in each preschool varied from as short as three quarters of an hour to as long as two hours. Nevertheless, this provided us with ample time to videotape anywhere from two to six target children per visit.

Settings. In conducting this study, we videotaped children attending two preschools in Taipei, Taiwan (Republic of China) and in five preschools in New York City (United States). All seven preschools are located in urban areas, Taipei and New York City, both of which rank very closely in terms of population density.

Participants. A total of 114 children, whose ages range from 4 years 0 months to 6 years 0 months, were videotaped, 24 from Taipei and 90 from New York City. The average age of the American sample is 4.92 (SD = 0.47), while, for the Taiwanese sample, the average age of the children is 5.13 (SD = 0.38).

Procedure. In conducting the present study, we employed the method of naturalistic observation (Ginsburg, Inoue & Seo, 1999; Ginsburg, Pappas & Seo, In press) and the same codes described early in this symposium by Seo.

Results

We began by examining the frequency of various types of mathematical activity of the American and Taiwanese children. Next we examined the levels of complexity of the most frequently occurring mathematical activities.

Preliminary data concerning gender. As in the findings on gender differences in the American sample discussed in the previous paper (Seo, Unpublished manuscript), we found no significant difference in the Taiwanese group in terms of the amount of time males and females were engaged in mathematical activity. Hence gender was ignored in further analyses of results.

Preliminary data concerning socioeconomic status (SES). Although, social class distinctions in Taiwan are not quite identical to those found in the U.S.—low-, middle-, and upper-income households—they do nevertheless exist. In general, the parents' occupations of the children who we videotaped fall into two categories: "working-class" parents (e.g. clerical and custodial positions) and "professional" parents (e.g. business owners, physicians, teachers). Again, like Seo's findings on social class with the American sample, 4- and 5-year-old Taiwanese children do not differ significantly in terms of time engaged in mathematical activity.

Cross-cultural Comparisons. We now ask: Which group spends more time involved in mathematical activity? Also, does one group spend more time in certain mathematical activities than in others? And if so, what are they? Figure 1 shows the average number of minutes spent on mathematical activity per child for both groups. Chinese children spent about 10 of the 15 minutes in mathematical activity and Americans about 6. The frequency is significantly higher for the Taiwanese group than the American group ($t = 3.81$, $p < .0001$).

We also examined the types of mathematical activity in which children of each group were engaged. Children in both groups were involved in Pattern and Shape more than any other mathematical activity (See Figure 2). Further, the Taiwanese children scored significantly higher on both Pattern and Shape and Spatial Relations activities than did the American children (t = 3.65 and 4.33, respectively, with $p < .0001$ for both).

Perhaps Chinese children scored higher on pattern shape because they played with Lego and blocks more frequently than did American children. We therefore next examined the frequency of Lego and block usage in the two groups. The results in Figure 3 show that Chinese children did indeed play more with these toys than did American children. But suppose we hold constant Lego and block play. Do Chinese children still demonstrate higher levels of pattern and shape activities than American children do? To determine this, we calculated the conditional probability that Pattern and Shape occurred given the use of Legos and blocks. Figure 4 shows the average conditional probabilities for the two groups. As the results indicate, the use of Legos and blocks in Pattern and Shape activity for the Taiwanese group is significantly higher than that of the American group ($t = 2.26$, with $p < .05$).

Comparison of Levels of Complexity. The Chinese children show a higher frequency of pattern and shape activity, with and without Lego and block play held constant. The Chinese children also show somewhat higher frequencies of Enumeration and Magnitude Comparison than Americans do, although the differences are not statistically significant.

The next question therefore is: How do the two groups compare in terms of complexity levels—not just frequency of occurrence—in Magnitude Comparison, Enumeration and Pattern and Shape? Our data concerning complexity levels in both Magnitude Comparison and Enumeration show no significant differences among the two groups. But we found that the Taiwanese children outdo their American peers in terms of the level of complexity of Pattern and Shape (See Figure 5). The Taiwanese children scored significantly higher than did their American peers ($t = 2.38$, $p < .05$). Figure 6 shows that many more American children were at level 1 of complexity, whereas more Chinese children were at the higher levels 3 and 4.

Complexity within Complexity—The Case of "Enumeration". As indicated above, nearly all studies that have conducted cross-national research in mathematical ability seem to agree that there is an East Asian advantage in enumeration or number concepts and calculation. Although we found no significant differences in frequency of enumeration in the everyday context or in its complexity, we wondered whether there might be subtle language differences within each level of complexity. In other words, might there be Chinese-American differences in language use within each level of complexity?

We therefore closely examined the enumeration language use by children in each group. Tables 1 and 2 offer a glimpse at the type of number words used by American and Taiwanese children within each of the four complexity levels of Enumeration. As these tables indicate, there are few if any differences; children of both groups either count or utter number words up to approximately "twenty." Only on rare occasions do they use numbers greater than this in their everyday activity. In general, Chinese and American children seem to use other mathematical language of similar complexity.

Discussion

Unlike earlier cross-national mathematics comparisons, our study focused not on in-school mathematical ability, but on young children's spontaneous mathematical thinking in the everyday context. Moreover, our study examined each group in terms of time spent on six aspects of mathematical behavior, not solely activities involving number.

What can be concluded in terms of spontaneous mathematical thinking among American and Taiwanese 4- and 5-year-old children in the everyday context? First, our study corroborates the findings of Ginsburg, Inoue and Seo (1999), who conclude that young children's mathematical thinking is not limited solely to counting and early arithmetic. Our findings, too, show that children of both groups are engaged in numerous mathematical activities. In particular, our findings indicate that the Taiwanese children's involvement in Pattern and Shape activities—which engender spatial and geometric thinking—is significantly more frequent and more complex than that of American children. This is a revealing outcome, given that the overwhelming majority of studies in cross-national research focus on mathematical abilities involving number and calculation, not on spatial or geometric relations. Perhaps this early Chinese advantage in spatial and geometric thinking contributes to their later superiority in academic achievement.

Next, we found that Chinese and American children do not differ in the frequency or complexity of Enumeration or Magnitude Comparison. Despite the potential advantage of Chinese counting language, Chinese children do not <u>use</u> more complex forms of counting than do Americans—at least in everyday play.

We also found that the use of certain objects seems to influence the type of mathematical activity in which the child is involved. For example, children's involvement in Lego and block play seems to be strongly associated with Pattern and Shape activity. The relations among objects, children's play with them, and children's mathematical thinking need further exploration. Perhaps certain objects afford special kinds of play and hence particular kinds of mathematical thinking.

Finally, the method of naturalistic observation seems promising for cross-national research, and for research on mathematical thinking in general. We need to supplement methods of tests and clinical interviewing with an examination of children's everyday behavior. Doing so may reveal surprising interests and competencies.

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Table 1

Categories of the Language Used in the "Enumeration" Complexity Level among U.S. children

	Level I	Level II	Level III	Level IV
	Saying Number Words	**Counting**	**Subitizing/ Estimation**	**Reading/Writing Numbers**
U.S.	• I'm five years old. • Your birthday is June 19 • I've got 15 million. • Testing. testing 1-2-3 • …so, I called 9-1-1	• One, two, three, four, five…take out five. • One, two, three, four, five…I've got five! • There's one, two, three…you can come in.	• We have four marbles together. • There are five people there. • I've got two, two at a time. • I've got two matches	(While reading numerals up to "twelve" on the computer) • one, two, three, one, two, three… • Zero, you ran out of time. • It's two against seven.

Table 2

Categories of the Language Used in the "Enumeration" Complexity Level among Taiwanese children

	Level I	Level II	Level III	Level IV
	Saying Number Words	**Counting**	**Subitizing/ Estimation**	**Reading/Writing Numbers**
Taiwan	• Another one • Eleven swan princes • Nineteen • Ninth month. first (September 1st) • Two O'clock • Eighth floor	• One person gets one place. • One, two, three, four, five, … eleven, twelve (One-to-one correspondence, using tagging method).	• Two magic wands. • Two are strong. • Make two [of something]. • Three pieces... • Three legs…	• One, three, one, nine… (Reading the numerals "1-3-1-9" on their drawing) • One, two, three, four, five, … eleven, twelve (Reading numerals while writing)

Figure 1

Average number of minutes that mathematical activity occurs (total of 15 min.)

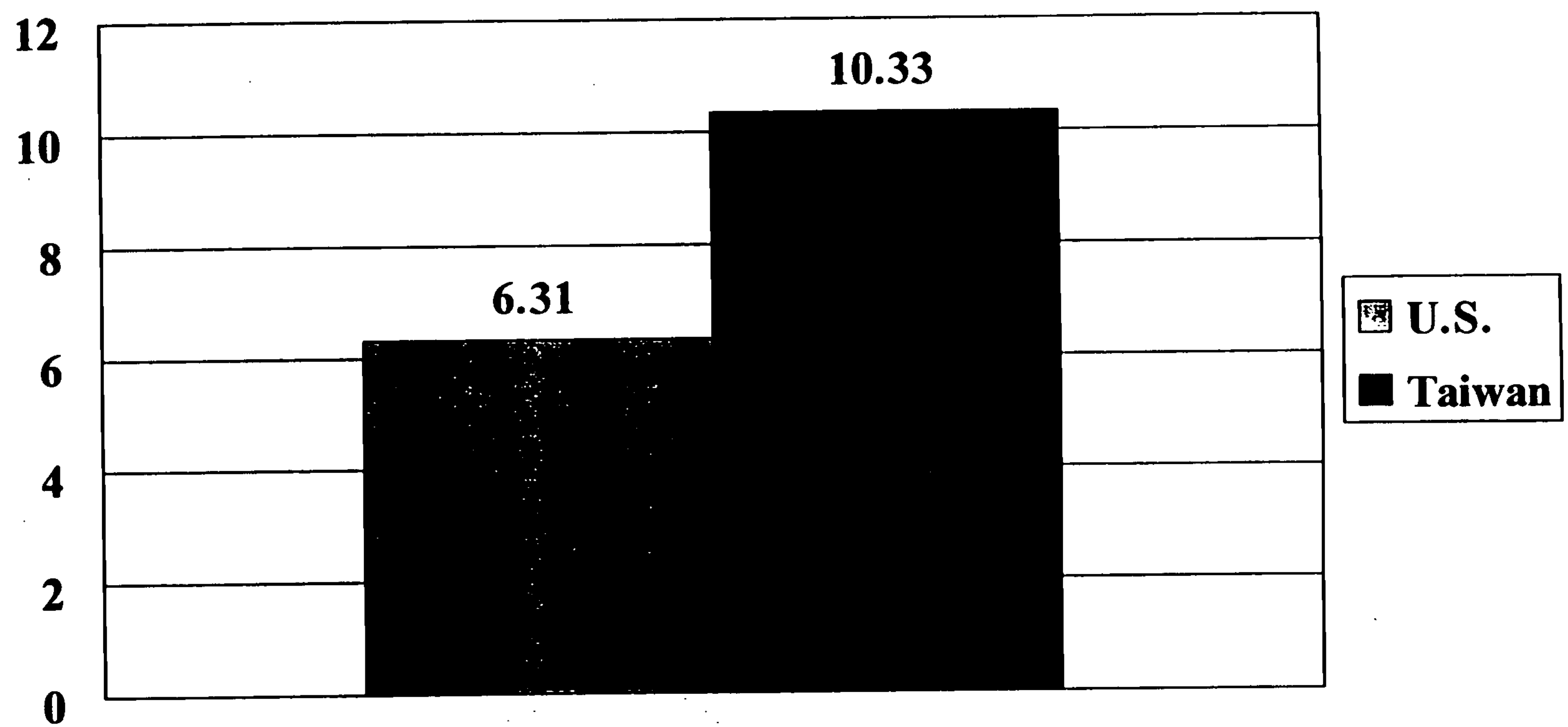

Figure 2

Average number of minutes (out of total 15 min.) spent on the 6 mathematical activities

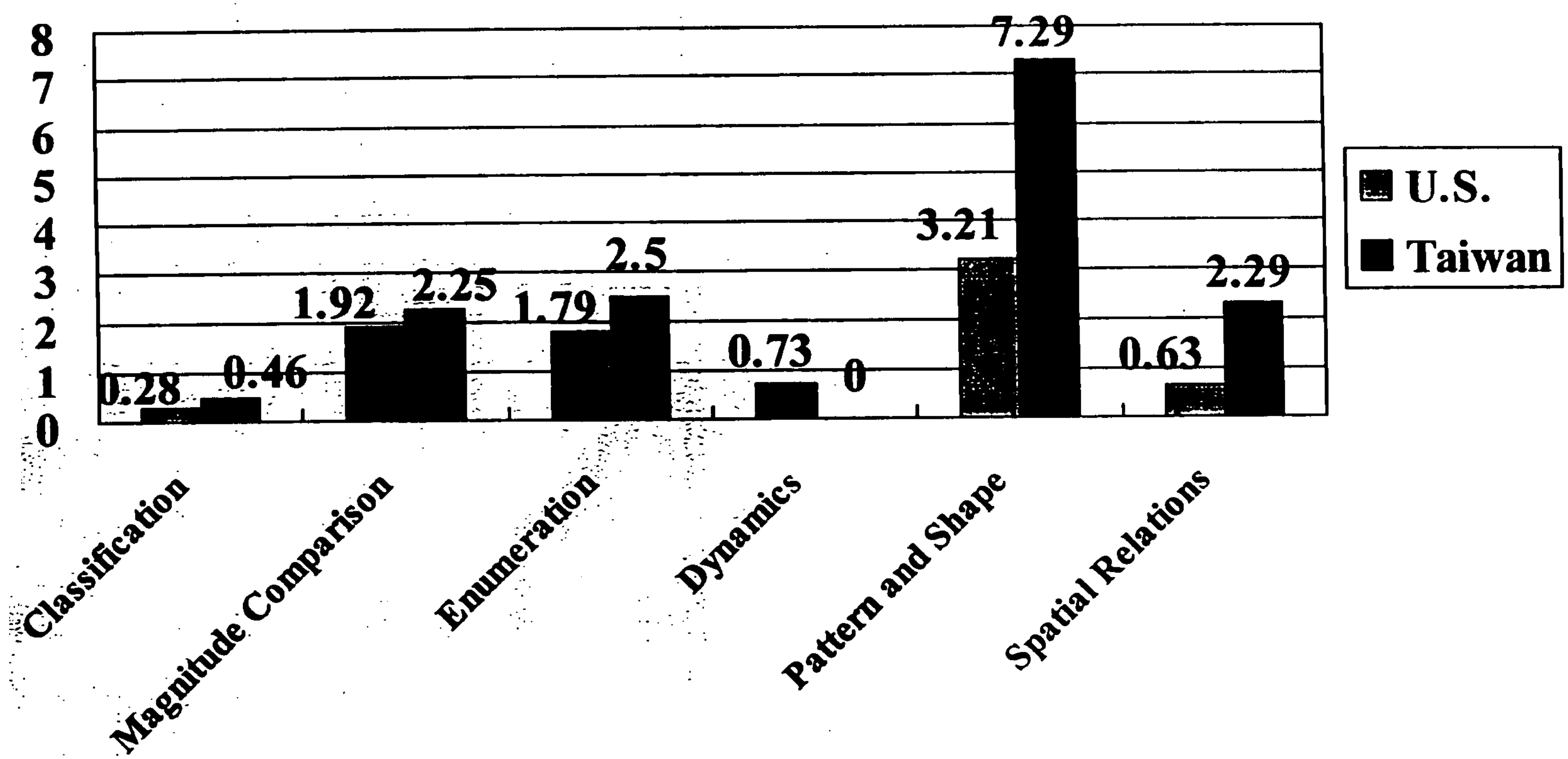

Figure 3

Frequencies of Lego and Block play

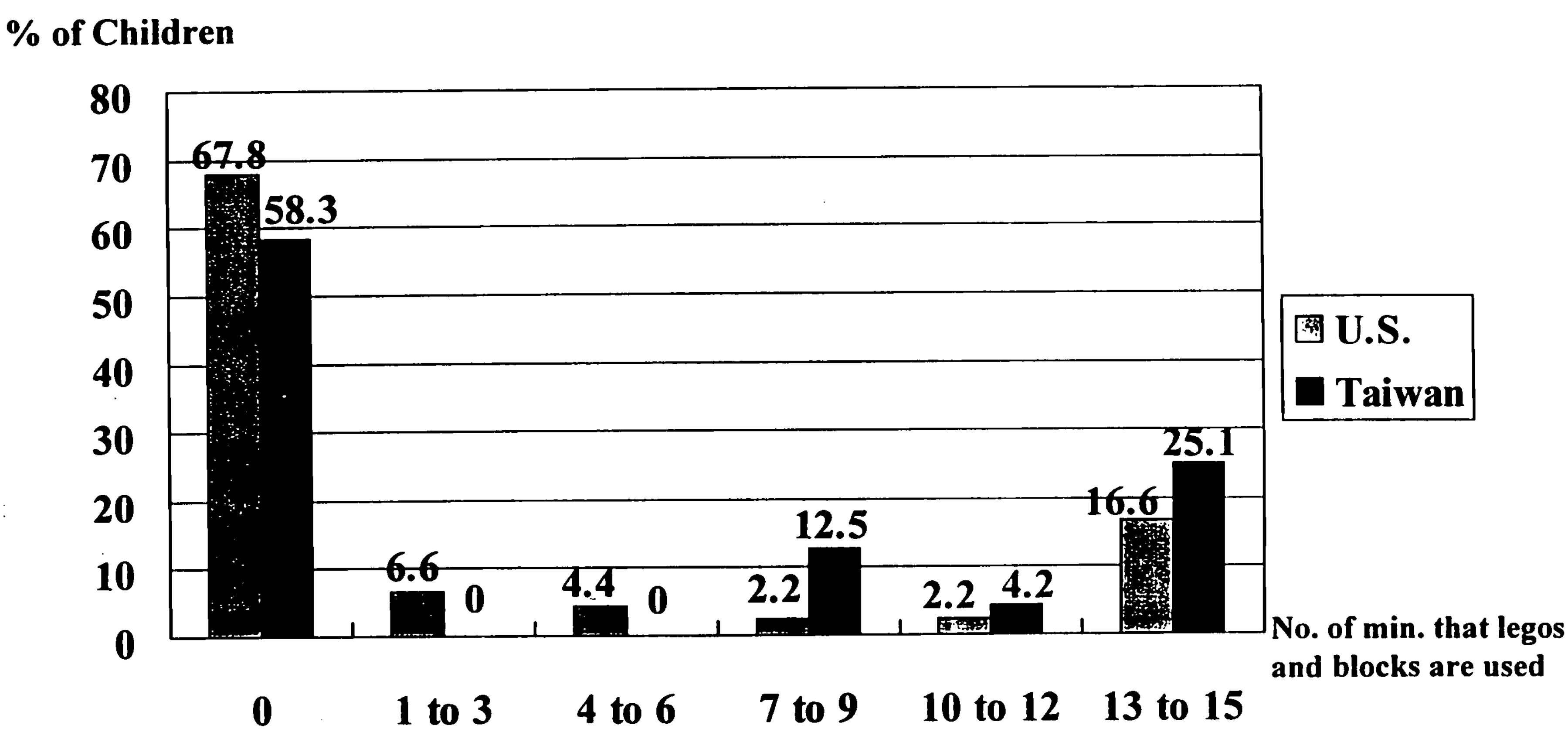

Figure 4

Mean conditional probabilities of Pattern and Shape given Legos/Blocks activity

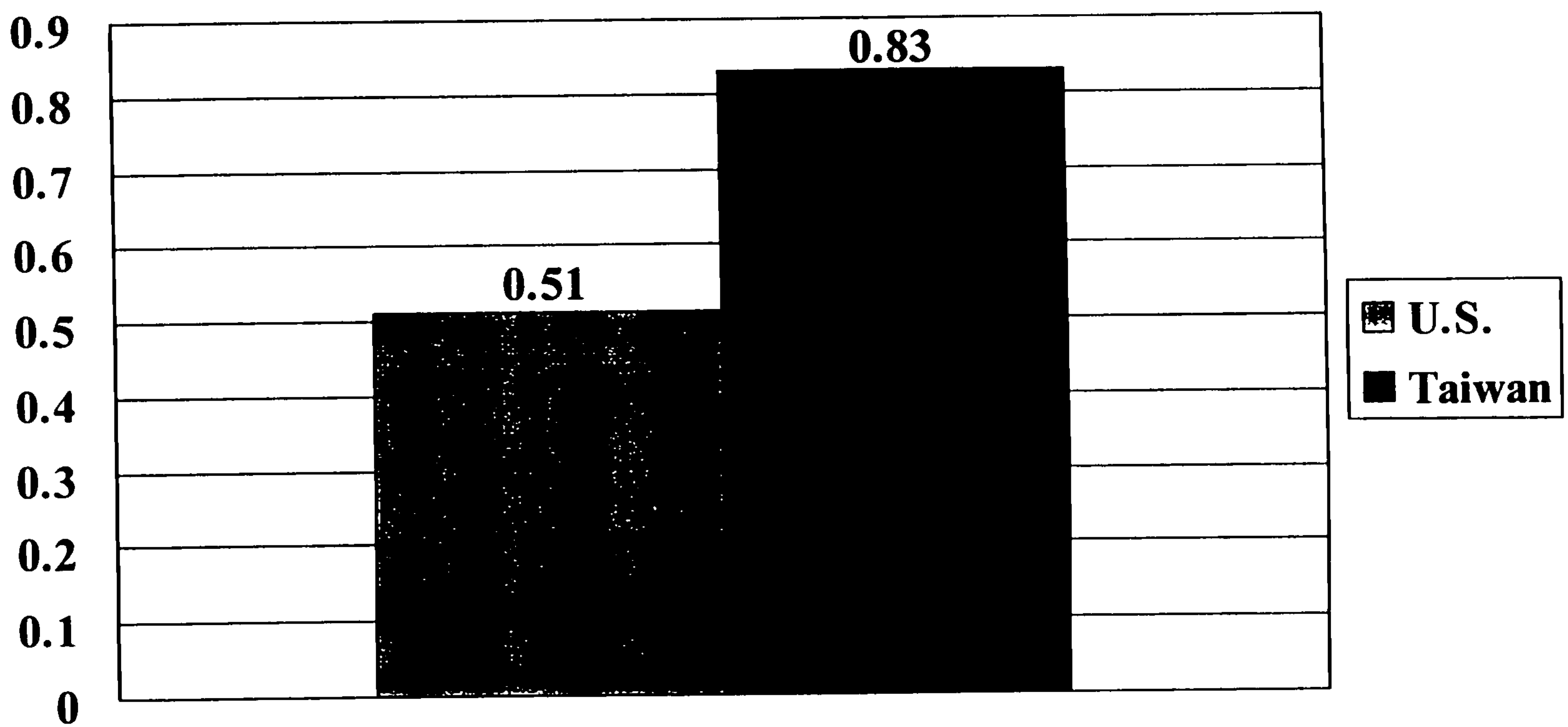

Figure 5

Mean complexity levels of Magnitude Comparison(MC)/Enumeration(EN)/Pattern and Shape(PS)--Range 1 to 4

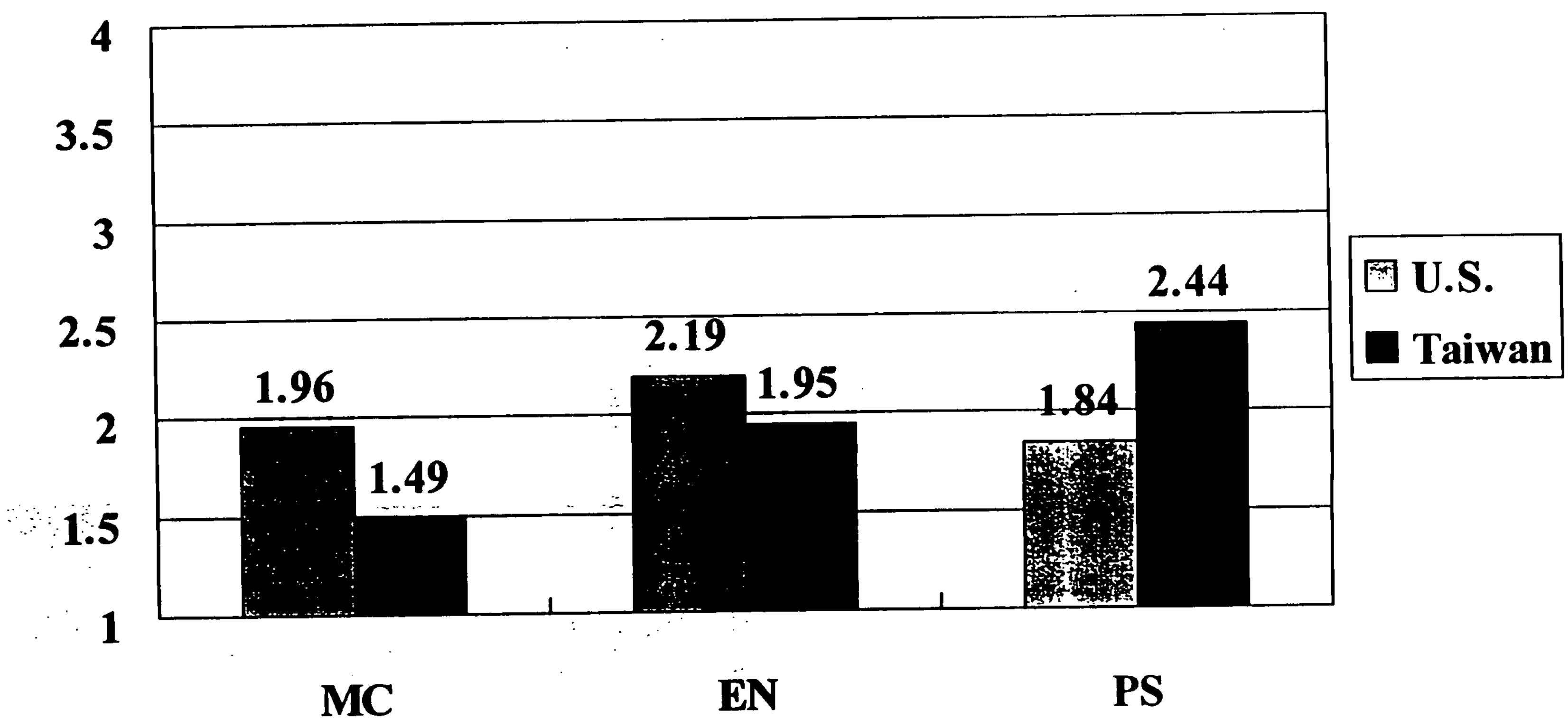

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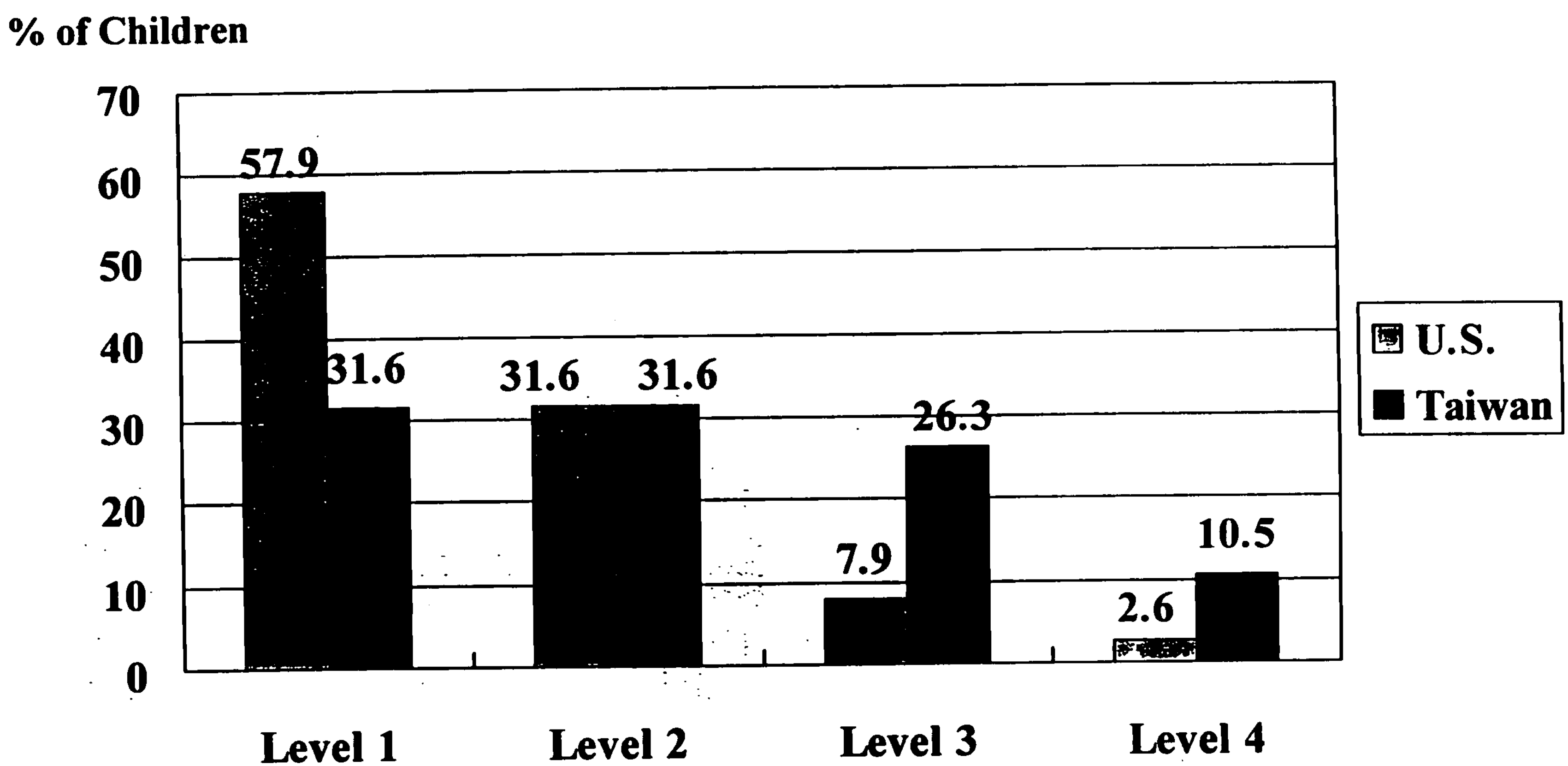
Figure 6

Frequencies of complexity levels of Pattern and Shape



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